LJ-86-36C

SOUTHWEST FISHERIES CENTER

SOUTHWEST FISHERIES CENTER
P.O. BOX 271
LA JOLLA, CA 92038

4/3
LJ
e 50

DECEMBER 1986

NATIONAL MARINE FISHERIES SERVICE
LIBRARY
APR 3 1987
National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

THE OCCURRENCE AND MOVEMENTS OF THE BOTTLENOSE DOLPHIN IN THE SOUTHERN CALIFORNIA BIGHT

By

R.H. Defran, Dennis L. Kelly, Gina M. Shultz,
Ann Ch. Weaver and Miriam A. Espinoza

ADMINISTRATIVE REPORT LJ-86-36C

This Administrative Report is issued as an informal document to ensure prompt dissemination of preliminary results, interim reports and special studies. We recommend that it not be abstracted or cited.

THE OCCURRENCE AND MOVEMENTS OF THE BOTTLENOSE DOLPHIN IN THE SOUTHERN CALIFORNIA BIGHT

by

R.H. Defran
Cetacean Behavior Laboratory
San Diego State University

Dennis L. Kelly
Coastal Dolphin Survey Project
Orange Coast College

Gina M. Shultz and Ann Ch. Weaver
Cetacean Behavior Laboratory
San Diego State Univeristy

Miriam A. Espinoza
Faculdad De Ciencias Marinas
Ensenada, B.C. Mexico

This report was prepared by R.H. Defran, Dennis L. Kelly, Gina M. Schultz, Ann Ch. Weaver, and Miriam A. Espinoza under contract No. 40JGNF5109 for the National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California. The statements, findings, conclusions and recommendations herein are those of the author and do not necessarily reflect the views of the National Marine Fisheries Service. Charles W. Oliver of the Southwest Fisheries Center Served as Contract Officer's Technical Representative for this contract.

ADMINISTRATIVE REPORT LJ-86-36C

CONTENTS

PAGE

INTRODUCTION..... 1

METHODOLOGY..... 2

Survey Procedure..... 2
Dorsal Fin Photographic Methodology..... 2
Cameras..... 2
Film..... 2
Dorsal Fin Identification..... 3
San Diego Study Area 4
Ensenada Study Area..... 4
Orange County Study Area..... 4

RESULTS..... 4

Sighting Number, Frequency and Location..... 4
School Size..... 5
Neonate Proportion..... 5
Dorsal Fin Photographic Analysis..... 6
Number of Individuals Identified..... 6
Number of Individuals Visiting the San Diego Study Area..... 6
Resight Percentages, Frequency and Distribution..... 7
Distribution of Resights..... 7
Resight Rate..... 7
Study Area Fidelity and Movement..... 8
Area Fidelity..... 8
Movements Between Areas..... 8
Turning Around..... 8

DISCUSSION..... 8

School Size..... 8
Neonate Proportion..... 9
Photographic Data..... 10
Number of Individuals..... 10
Resights..... 10
Conclusion..... 11

ACKNOWLEDGMENTS..... 12

REFERENCES..... 14

LIST OF TABLES

TABLE		PAGE
1	Sighting and photographic resight data for *Tursiops truncatus* in the San Diego Study Area.....	16
2	Sighting and photographic resight data for *Tursiops truncatus* in the Ensenada Study Area.....	18
3.	Sighting and photographic resight data for *Tursiops truncatus* in the Orange County Study Area. Blank spaces indicate missing data.....	19
4.	Group size mean, standard deviation, median, range and totals for San Diego, Ensenada and Orange County study area.....	20
5.	Proportion of photographically identifiable animals which were resighted. Proportions are presented in blocks of 5 trips where at least one animal was identified. Dates of the first and last trip of each block are given.....	21

LIST OF FIGURES

FIGURES		PAGE
1.	Computation of dorsal ratio. See text for details.....	22
2.	Map of the San Diego Study Area. Insert shows relative location of Orange County, San Diego and Ensendada Study areas.....	23
3.	Map of Ensenada Study Area.....	24
4.	Map of Orange County Study Area.....	25

Occurrence and Movements of the Bottlenose Dolphin in the Southern California Bight

by

R.H Defran, Dennis L. Kelly, Gina M. Shultz,
Ann Ch. Weaver, and Miraim A. Espinoza

INTRODUCTION

The movements of an organism within its habitat is an important life history parameter in the biological analysis of most behaviorally advanced animals. Recent reviews of the ecology of bottlenose dolphins (Tursiops truncatus) have stressed the existence of definable home ranges in this species (Shane, Wells and Wursig, 1986; Wells, Irvine and Scott, 1980). The strongest evidence for year round and seasonal home ranges in bottlenose dolphins comes from studies on the Atlantic form of the species by Wells et al. (1980), Shane (1977, 1980), Gruber (1981) and Wursig and Wursig (1979).

In the present research we studied the coastal Pacific form of T. truncatus in several adjacent study areas located in the northern end of this species' presumed range. An important goal of this work was to document whether individuals in this population made regular use of specific coastal strips and to what degree there was movement between these areas. Previous research by Hansen (1983), whose study area partially overlapped the one described in the current work, concluded that his study area served as a home range for a number of individuals and a portion of the home range for other individuals. Hansen further hypothesized that cool water upwellings from deep underwater canyons as well as land promontories may have functioned as barriers to north - south movement, leading to a degree of genetic isolation.

In contrast to Hansen's conclusions, recent work by Defran, Shultz, Espinoza and Weaver (1985) suggested that coastal movement rather than local residency was characteristic of this open coastline population. The current research involved extensive year round observation within the same area studied by Hansen as well as in areas to the north and south. We were, therefore, able to evaluate this species'use of the habitat within the Southern California Bight.

An additional goal of the present research was to accumulate normative data on population parameters such as school size and age composition (neonate proportion).

METHODOLOGY

The present research combined data from two independent but concurrent investigations covering three study areas. All observations reported below are derived from boat based photographic surveys which employed the same general survey methodology and identical photo identification techniques.

One of the principal investigators (Defran) carried out observations along the northern coastline of San Diego County, California, and along the coast south of Ensenada, Baja California. The other principal investigator (Kelly) carried out observations along the coastline of Orange County, California.

Survey Procedure

In all study areas a typical survey involved travel 50 to 100 meters just outside the surf line until a school of dolphins was sighted. The boat then progressed about one km past the closest animals to determine the size of the aggregation. The boat then returned to an offshore vantage point about 200 to 300 meters from the animals where data were collected on the following variables: a) number of dolphins sighted; b) school size; c) proportion of neonates within a school. Photographs were taken of as many individuals as possible and contact with the animals was maintained until photographic and other census work was completed. Tables 1 - 3 present information on the dates surveys were carried out as well as times and latitude of sightings in all three study areas.

Dorsal Fin Photographic Methodology

A Dorsal Fin Photographic Laboratory was established at San Diego State University and new methodology was developed for the analysis of the naturally occurring variations (notches) in the dorsal fin of *T. truncatus*. The current technique is simple, easily learned by laboratory personnel, reliably identifies animals as resights or new additions to the catalogue, and permits inexpensive exchange of dorsal fin data among laboratories.

Cameras. The majority of all photographs taken have been with a Canon A-1 equipped with a Canon 400 mm lens and a high speed motor drive (5 exposures/sec) A second camera, a Canon AE-1 equipped with a motorized filmwinder and a 50 mm lens was also used. The second camera served as a backup and permitted photographs when the animals were too close for long lens photography.

Film. Over the course of the study period several film types have been employed. Satisfactory identification has been possible with all types but some have had economic and convenience advantages. The bulk of our photographic work has been with Ektachrome slide film with either ASA values of 64 and 100. Under cloudy conditions such as those sometimes encountered

in the Ensenada study area 100 ASA Ektachrome was "pushed" to 400 ASA with satisfactory results. More recently we have begun shooting Tri-X black and white print film although photo identification work is done from developed negatives. There are several advantages to this technique. First, the 400 ASA value of the film permits fast shutter speeds (1/250 - 1/100 sec) to be used under most circumstances. Secondly, the reverse negatives provide good contrast which in turn permits easy tracing (see below) and easier photo identification. Thirdly, this approach permits us to reduce the cost of the film and development to about $4.35 which is about $1.50 less expensive than Ektachrome slides. Finally, we can usually obtain one day turn-around time on film development. Once the negatives are sorted they are mounted in slide holders.

Dorsal Fin Identification. The present method begins with a collection of dated (mm/dd/yy) slides from a photographic survey which are sorted into duplicates of the same animal. Only clear slides of dorsal fins with very distinctive single notches or those with more than one notch are retained. The best slide of each animal is given a temporary identification number and the remainder are filed by date in the Extra Slide Catalogue. Our current estimate is that 65% of all dorsal fins in a group of dolphins are photographically identifiable. The foundation for this estimate is described more fully in the Results section.

Slides of dorsal fins are then projected and enlarged to fill a 10 cm X 17 cm frame drawn on white paper and the contours of the fin are traced. As shown in Figure 1 the top point of the two largest notches are labeled A (top) and B (bottom). If notches don't differ in size then the two farthest notches are designated. The dorsal fin is then coded as the ratio of: distance between A and B divided by the distance from B to the top of the dorsal fin. As a relative measure this Dorsal Ratio is unaffected by the size of the dorsal when photographed, enlarged, or even under severe cases of parallax.

Subject Numbers are then assigned and recorded on tracings which are filed by Dorsal Ratio within one of three Tracing Volumes: A) Fins with One or a Top Notch; B) Fins with Two or Three Notches; C) Fins with Four or More Notches. All tracings of the same dorsal fin are filed together with the most recent used for resight matches. When a tracing within the relevant volume cannot be matched by Dorsal Ratio ($\pm$.05) all tracings within all volumes are inspected. This latter procedure, though infrequently needed and labor intensive ensures that previously sighted dorsal fins with new notches will be resighted. When a tracing is matched the current and previous slides are compared and must also be a match before a resight can be confirmed. A separate Dorsal Sighting Catalogue is also maintained which is organized by Subject Number and cross-references Sight and Resight dates, Tracing Volume and Dorsal Ratios.

The initial catalogue consisted of dorsal photographs of 118 individuals selected from those taken by Hansen (1983) and others

at the National Marine Fisheries Service (NMFS), Southwest Laboratory, La Jolla, California between 1981 - 1983. In the remainder of this manuscript these photographs are referred to as the NMFS sample. Photographs taken within the San Diego study area after 1/84 are referred to as the Cetacean Behavior Laboratory (CBL) sample.

San Diego Study Area

Between 1/84 - 5/86, 80 surveys were carried out within an area bordered in the south by Scripps Pier, La Jolla. Prior to 6/85 the northern boundary of the study area was Oceanside Harbor (41 km). The northern border of the study area was changed to South Carlsbad (31 km) after 6/85 because animals were infrequently sighted north of there. Figure 2 shows an overview map of the San Diego, Ensenada, and Orange County study areas (insert) as well as the coastal contours of the San Diego study area.

Eight of the surveys between 1/84 and 5/85 and all surveys after 1/86 extended to the northern limit of the study area. All other surveys were terminated after photographing the first school of animals encountered. The survey vessel was a a 17' Boston Whaler with a 70 hp Johnson outboard motor.

Ensenada Study Area

Ten surveys were conducted between 4/85 - 6/86 along the coastline 15 km south of Ensenada, Baja, California (Figure 3). Surveys began in the open bay outside of Ensenada Harbor and progressed southward toward La Joya, a protected area near Punta Banda. All surveys extended to the southern limit of the study area. Ensenada data was sometimes combined with San Diego data because of the small number of surveys carried out in Ensenada and because estimates in both these study areas were made by the same research team employing more identical criteria. The survey vessel was a 15' aluminum boat with a 25 hp Mercury outboard engine.

Orange County Study Area

Between 10/82 and 2/86 thirty-five surveys were carried out along the coastal waters off Orange County between Anaheim Bay in the north and San Onofre State Beach in the south (Figure 4). Nineteen surveys were of the entire study area while 13 surveyed only the northern portion and 3 only the southern portion. The survey vessel was a 23' Seacraft with a Ford 351 inboard/outboard motor.

RESULTS

Sighting Number, Frequency and Location

As shown in Table 1, a total of 1544 sightings were made during surveys in all three study areas. Dolphins were sighted

on 77% of all surveys carried out in both the San Diego and Orange County study areas while in Ensenada, 70% of the surveys resulted in a sighting. Within the San Diego and Ensenada study areas 57% of all surveys where no dolphins were sighted took place between the months of August and October.

Most sightings within the San Diego study area were in the southern portion between Solana Beach and Torrey Pines State Park. In the Orange County study area sightings were concentrated in the northern portion while in Ensenada dolphins were sighted equally across all sections of the study area.

School Size

During most surveys animals were observed to coalesce into larger aggregations and separate into smaller ones. Usually, these smaller aggregations remained within .5 km of each other. It is likely that on some occasions the presence and movements of the survey vessel stimulated some of these movements. The direction or degree of this contribution is unknown but presumed to be small (Wursig and Wursig, 1979).

In all cases dolphins were seen in the company of at least one other dolphin, though the size of these dolphin schools varied considerably both during and between surveys (see description below). Estimates of school size were in part a function of survey methodology including the definition of a school which we adopted.

As noted above, when an aggregation was spotted it was our practice to continue past the school about one km to confirm its geographic limits. On all but a few occasions when we encountered a second aggregation they soon joined the first school sighted. Because it was not possible to document the variations or the variables related to school size, we based our estimates of school size on the largest aggregation achieved by the animals during a survey. The largest school sighted consisted of 90 animals (San Diego study area on 2/8/85) which was almost twice as large as any other aggregation observed in any study area. On this occasion animals were observed in continuous association between the north end of Torrey Pines State Park and the southern end of the study area, a distance of 5.5 km. Table 1 summarizes additional data on school size and shows that the median school size in the San Diego and Ensenada study areas (combined) was lower (Med = 11) and the standard deviation considerably higher (Std. Dev = 15) than in the Orange County study area.

Neonate Proportion

The proportion of neonates within the population provides a rough estimate of reproductive rate. In the field, visual identification of an animal as a neonate is usually a straightforward process and was based on an animal meeting one or

more size, coloration and behavioral criteria.

The proportion of neonates within a school was summarized by month and across years for the San Diego and Ensenada (combined) and Orange County study areas. Monthly average proportions of 9.5% and 8.5% respectively were similar for these two independently derived estimates.

Dorsal Fin Photographic Analysis

Number of Individuals Identified

Photographs taken within the San Diego study area between 1/84 and 5/86 have identified a total of 207 individuals with distinctive dorsal fins. When data from the NMFS sample was combined with data from the CBL sample the total number of individuals identified was 264.

The number of individuals identified within the Orange County and Ensenada study areas was 103 and 71 respectively. Overlap between individuals photographed in the different study areas will be discussed below.

Number of Individuals Visiting the San Diego Study Area

The number of individuals which have been photographically identified may be used to make an estimate of minimal number of individuals who have visited the San Diego study area. Estimating the minimal number of animals to visit a study area begins with a consideration of the proportion of photographically identifiable animals in the observed samples.

It was often possible to observe the notch pattern of individuals in a school while photographing them. Members of the research team were asked to make subjective estimates of the number of animals with photographically distinct dorsal fins. Estimates ranged between 60 to 70 percent and averaged 65%. Neonates and small sub-adults accounted for a majority of the 35% without distinctive fins. Nine percent of the animals we observed were neonates and all of these had smooth fins. Smaller animals, judged to be sub-adults (Sergeant, Caldwell and Caldwell, 1973) also had characteristically smooth or single-notched fins. Therefore, sub-adults would only have to number 26% of the population to support our estimate of 65% having distinctive fins. Size/age distribution data presented by Wells (1978) from capture operations on 100 bottlenose dolphins in the Gulf of Mexico showed that 48% of their animals were either calves or sub-adults. Even allowing for selection bias in the capture process, their data support the current estimate and suggest it may even be conservative.

The number of identified individuals (CBL = 207, CBL + NMFS = 264) may be incremented by 35% to provide a minimal estimate of the number of individuals who have visited the San Diego study area. Between 1/84 - 5/86 (CBL data only) the estimate would be

318 while between 9/81 - 5/86 (NMFS + CBL data) the estimate would be 406.

Resight Percentages, Frequency and Distribution

During the current study period 75 of the 207 animals identified (36%) were sighted more than once in the San Diego study area. Among those animals which were resighted, the average resights per animal was 2.7. The resight percentage of animals from the NMFS sample was similar to the CBL data presented above. Thirty-six percent of the 118 NMFS animals were sighted at least once during the current study period while 64% were not photographed again at all.

Hansen (1983) identified 21 NMFS animals as a subset which had been photographed 5 or more times during the course of his study period. We examined the sighting frequency of this subset and found the following: ten individuals were never photographed in the San Diego Study area within the course of the current study period. Of the remaining 11 animals which were photographed again, 7 were also sighted within the Orange County study area. However, one of the animals photographed by Hansen most frequently (n = 9) was also one of the few animals photographed most frequently by us (n = 6) and only in the San Diego study area.

Distribution of Resights

The significance of an animal's resight frequency must be considered in conjunction with the frequency with which surveys were carried out as well as the duration of the study period. Considered together these variables reflect the dimension of survey effort. The average interval between surveys was 11 days while the average interval between CBL resights was 228 days. That is, resighted animals were photographed an average of once every 21 surveys.

In order to evaluate the possibility that dolphins maintain short-term residency within an area we examined survey and resight data to find the period of time in which surveys had been carried out most frequently. Between 6/15/84 and 8/28/84 we completed 10 surveys which resulted in at least one photograph of an identifiable fin. During this period a total of 57 animals were photographed which included 53 individuals photographed once and four photographed twice each. This resight rate (7%) is considerably lower than the overall rate.

Resight Rate

The proportion of resights to new sightings as a function of the number of surveys was also analyzed for animals in the San Diego study area. Table 2 presents resight proportions across blocks of six surveys for CBL & NMFS data and CBL Only data.

With the exception of Block 4, which included a small number of photographed animals, the functions are monotonic and reflect resight proportions with asymptotes of between 75% to 80%.

Study Area Fidelity and Movements

Photographic data was evaluated for possible evidence of an individual or school's fidelity to a particular study area and for movements between study areas. Emphasis in these analyses was again placed on data from the San Diego study area where data collection was most comprehensive and observed trends the most likely to be representative.

Area Fidelity. During the current study period, 164 of the 264 individuals (62%) sighted in the San Diego study area (CBL and NMFS samples combined) were never sighted in either the Orange County or Ensenada study areas. Further, 46% of these "San Diego Only" animals (n = 75) were photographed only once and another 20% were photographed only twice (n = 33).

Movements Between Areas. Seventy-six percent (n = 103) of all individuals photographed in the Orange County study area also were sighted in the Diego study area. This sample includes 74 individuals photographed in San Diego and four sighted in Ensenada and presumed to have passed through the San Diego area. Twenty-one of the 25 'Orange County Only' sightings were sighted only once and none more than two times.

Sixty-nine percent of the 71 individuals sighted in Ensenada were sighted in the San Diego study area, including the four Ensenada - Orange County individuals mentioned above. Thirteen of 22 'Ensenada Only' individuals were among the most recently photographed (between 5/86 - 6/86) and therefore had minimal opportunity to be resighted. All but one of these individuals were photographed only once.

Turning Around. Evidence for 'back and forth' movements comes from the number of animals which were documented to 'turn around'. A 'turn around' was scored, for example when an animal was identified in the San Diego study area, then in either Orange County or Ensenada and then back again in San Diego. Other 'turn around' combinations, too lengthy to list, were also possible. Fifty-seven of the 318 animals (18%) identified in all three study areas were documented to 'turn around'. Considering the less frequent surveys in Orange County and especially Ensenada (vis-a-vis San Diego) these 'turn around' frequencies are probably low and, therefore, conservative.

DISCUSSION

School Size

Shane et al. (1986) have summarized some of the important methodological and theoretical considerations involved in the analysis of school size in bottlenose dolphins. These authors

rightly note that variability in school size may be a product of the definition of a cetacean "school" as well as an ecological issues.

The median school size values obtained in the present work ranged from 11 (San Diego & Ensenada combined) to 22 (Orange County) and were typical of the values reported by others for this species (Shane et al., 1986). We noted as others have (e.g, Shane et al., 1986; Wells et al., 1980) that aggregations of bottlenose dolphins frequently engage in an apparently fluid process of division and coalition. Such variations in school size are probably under the control of a variety of variables including the social dynamics among conspecifics, characteristics of prey species and the physical features of the marine ecology. It was beyond the scope or goals of the present work to document the variations which occurred in school size or the possible variables affecting such variations. Thus, the current data probably reflect the upper limits of school size in this population of bottlenose dolphins.

Neonate Proportion

Approximately 9.0% of the animals observed in all three study areas were neonates. Several features of the data suggest that these percentages are representative. First, nearly equivalent neonate proportions were obtained from independent assessments in adjacent study areas (San Diego/Ensenada = 9.5%; Orange County = 8.5%). Also, the low photographic resight values discussed below argue against the existence of geographical preferences (site fidelity) for the study areas. If such preferences existed among mothers with neonates, then neonate proportions within the study area might have been spuriously inflated. However, individuals old enough to bear calves would also be good candidates for photographic identification. Resight values were low, however, which argues against mechanisms of site fidelity for mothers with calves or any other sub-set of the studied population.

The 9% neonate proportions reported in the present research are based on year-round observation conducted over a period of several years. Only a small portion of the neonate percentages reported in the literature (Gruber, 1981; Leatherwood and Reeves, 1980) are based on year-round observations. Data based on such long-term observation has been reported in studies by Wells and his colleagues in the Sarasota study area (Irvine, Scott, Wells and Kaufmann, 1979) and by Shane (Shane, 1977, 1980) and Gruber (1981) along the Gulf coast of Texas as well as by Hansen (1983). Among these studies, most have reported neonate proportions of approximately 7.0 %. The low proportion reported in the Sarasota study area (4.0%) probably reflects the maximum reproductive rate which can be maintained by that relatively isolated environment.

Photographic Data

Number of Individuals

Extensive surveys carried out in the San Diego, Orange County and Ensenada study areas confirmed that these coastal zones are regularly visited by bottlenose dolphins. Specifically, at least 318 individuals were estimated to have visited the San Diego study area over a 29 month period. When the study period was extended to include the 16 months of the Hansen (1983) study (9/81 to 1/83) the number of animals estimated to have visited the San Diego study area increased to 406. This number may be contrasted with the range of 173 - 240 predicted by Hansen in his population estimates.

The validity of our estimates rests on a number of assumptions: 1) that the likelihood of photographically distinct and non-distinct individuals visiting a study area is identical and that 2) Identified and unidentified animals are randomly distributed; 3) animals once identified are always correctly identified thereafter, i.e. no loss of marks; 4) all photographically identifiable individuals in a school are photographed and correctly identified; 5) correction factor is correct.

There is no 'a priori' reason for discarding Assumption 1, 2 and 5. We judge that Assumption 3 was met to a reasonable degree because we restricted ourselves to using clear slides of photographically distinct dorsal fins. Further, we were often able to document alterations in the notch pattern of previously photographed animals. The proportion of identifiable animals which are actually photographed (Assumption 4) probably approached 100% when the school size was small and declined when school size was large. The net effect of this latter consideration is that these minimal estimates are probably quite conservative as estimates of the total number of animals to visit this study area.

Resights

Photographic data from the present study showed that the majority of individuals (64%) who were photographed in the San Diego study area were sighted only once. Those animals which were photographed more than once were sighted an average of less than three times and only an average of once every twenty-second surveys. Further, no evidence was found which identified any individual as a year-round or even a seasonal resident of the San Diego study area. Along similar lines, Hansen (1983) drew special attention to a subset of 21 animals from his sample which had been photographed during his study period 5 or more times. During the current work approximately 50% of these suggested "residents" were not photographed while 33% were photographed in the Orange County study area.

In another analysis, animals photographed only in San Diego (n = 164) and not in Orange County or Ensenada were specifically evaluated for possible "resident" status. Fourty-six percent of these "San Diego Only" animals were photographed only once, while another 20% were photographed only twice.

A high percentage of the individuals photographed in the Orange County (76%) and Ensenada (69%) study areas were also photographed in the San Diego study area. Such overlap indicates that coastal movement rather than 'local residency' is characteristic of the Pacific coast form of Tursiops truncatus.

Further evidence of extended coastal travel comes from documented back and forth movements between study areas. The most common form of this direction reversal involved sighting an individual in the Orange County study area in between sightings in the San Diego study area. The more limited number of surveys carried out in the Orange County and Ensenada study areas made instances of 'turning around' difficult to document. Therefore, the 18% that were documented to turn around is probably a low and quite conservative estimate of the frequency of this pattern. Other documentation of extended coastal travel comes from a report by Wells, Dohl, Hansen, Baldridge and Kelly (1983) who reported sightiing five individuals from Hansen's (1983) sample 750 km to the north in the coastal waters near Monterey.

Finally, the data presented in Table 2 shows that the proportion of resighted to newly sighted animals in the San Diego study area increased over the duration of the study period. Based on the trend seen in the NMFS & CBL data, the CBL Only proportion appeared to reach asymptote at approximately 75% to 80%. The high resight proportion and the low frequency of resights mentioned earlier appear to be inconsistent with each other. These two features of the data may be reconciled by noting that, in general, many of the resighted animals contributing to the high resight proportion are those which had not been resighted in the past or who had been resighted only once. Considering the 29 month study period duration the following generalization seems to be supported by this data: An increasingly higher percentage of the animals within the San Diego study area have been sighted here before but resight frequency was low and the interval between sightings was long.

Conclusion

It is our conclusion that the San Diego study area does not function as a definable home range for the coastal population of bottlenose dolphins. However, it is clear from the present data that a substantial portion of the individuals who visit the study area eventually return. Taken together, the available evidence is most consistent with a model which involves frequent although irregular travel up and down a portion of the coastline. The limits of this range are indeterminate but probably are considerably greater than the distance between the southern limits of the San Diego and the northern limits of the Orange

County study areas. Most often, animals appear to move through an area rather than stay for a period of time.

It seems likely that the open coastline feature of the Southern California Bight habitat promotes movement or at the very least does not support fidelity to an area. The mediating mechanism through which movement is promoted is not clear, however. The mechanism may have more to do with the availability of food sources than the presence or absence of protection per se.

Long term studies incorporating more northerly segments of the range are needed to document the limits of this species' range. Also, extensions of this work in both northerly, southerly and offshore directions will add important information about the range limits of some of the individuals already identified. Because of the extensive catalogue of individuals observed along the coastal zone, surveys along the offshore California islands such as Santa Catalina and the Channel Islands off Santa Barbara, as well as the offshore islands along the Mexican coast are more likely to shed light on the possible existence of inshore and offshore forms of bottlenose dolphins. (Duffield, Ridgway and Cornell, 1983; Mitchell, 1975; Walker, 1981)

Continued and extended photographic surveys will also more fully reveal the impact of ecological alterations such as the "El Nino" phenomenon as well as possible seasonal and migratory movement patterns of the Pacific coast population of T. truncatus. Data on the movements of bottlenose dolphins must eventually be integrated with other information on its prey availability and prey selection. The net effect will be a clearer picture of this species feeding ecology and a broader view of its function within the coastal and possibly offshore habitat.

ACKNOWLEDGMENTS

Work carried out in the San Diego and Ensenada study areas was supported in part by the following San Diego State University institutions and individuals: The Foundation - Faculty Grant-in-Aid; The Center for Marine Studies and particularly Don Kent whose management of the Center's boat facility kept us safely afloat and moving in San Diego waters. In Ensenada, Vicente Ferreira was our captain and guide and always kept us offshore of the big ones rolling into Mona Lisa Beach. Muchas Gracias.

Work carried out in the Orange County study area was supported in part by the Orange County chapter of the American Cetacean Society and the folowing Orange Coast College instituitions: 1) The Coastal Dolphin Survey Project; 2) The Marine Mammal Research Group; 3) The Associated Students.

The authors also wish to acknowledge the on-board help and the overboard bravery of Leslie A. Tipton who single-handedly

disproved the myth that dolphins will save a drowning sailor. The authors also wish to thank Charlene Walsh and Sally DeMaster who

made important contributions to the process of data collection and analysis during the early stages of this work.

Much gratitude is extended to two individuals who spent their summer helping us complete what Solzenhietzen called "the final inch". Michelle Krammer was careful, systematic and long laboring in putting our data into a computer-digestible form. She also carried out many of the statistical summaries on this same data. Aaron Weinfield worked his substantial skills as a Dbase III programmer to our advantage. His programs greatly facilitated our analysis of the data in the present report and established a system for updating the dorsal catalogue in the future. Thank you both.

Special appreciation is also extended to Larry Hansen, Chuck Oliver, Doug DeMaster, Aleta Hohn and Peter Bryant. Larry introduced us to this work and helped us in every way while we learned the ropes. Chuck was our liaison at NMFS and facilitated valuable equipment support as well as providing feedback on early drafts of this manuscript. Doug, Aleta and Peter provided important comprehensive and technical feedback on later drafts of this manuscript.

REFERENCES

Defran, R.H., Shultz, G.A., Espinoza, M.A. and Weaver, A.Ch. 1985. The population biology of Tursiops truncatus along the southern California and northern Baja coastline. Sixth Biennial Conference on the Biology of Marine Mammals, November 22-26, Vancouver, British Colombia, Canada

Duffield, D., Ridgway, S. and Cornell, L. 1983. Hematology distinguishes coastal and offshore forms of dolphins (Tursiops). Canadian Journal of Zoology, 1961, 930-933.

Gruber, J.A. 1981. Ecology of the Atlantic bottlenosed dolphin, (Tursiops truncatus) in the Pass Cavallo area of Madagorda Bay. Texas. M.Sc. thesis. Texas A & M University, College Station, TX 77843

Hansen, L. J. 1983. Population biology of the coastal bottlenose dolphin (T. truncatus) of Southern California. M. A. thesis, Sacramento State University, Sacramento, Ca. 104 pages.

Leatherwood, J.S. and R. R. Reeves. 1982. Bottlenose dolphin Tursiops truncatus and other toothed cetaceans. pp. 369-414. In J.A. Chapman and G.A. Feldhamer, (Eds.) Wild mammals of North America: biology, management, economics. The John Hopkins University Press, Baltimore, Maryland. 1147 pp.

Mitchell, E. 1975. Review of biology and fisheries of smaller cetaceans. Journal of the Fisheries Research Board of Canada, 32, 923-925.

Sergeant, D.E., D.K. Caldwell and M.C. Caldwell. 1973. Age, growth, and maturity of bottlenosed dolphin (Tursiops truncatus) from northeast Florida. J. Fisheries Res. Board Can., 30, 1009-1011.

Shane, S. H. 1977. The population biology of the Atlantic bottlenose dolphin, Tursiops truncatus in the Aransas Pass area of Texas. M.Sc. thesis, Texas A. & M. University, College Station, Texas. 239 pp.

Shane, S.H. 1980. Occurrence, movements and distribution of bottlenose dolphins, Tursiops truncatus, in southern Texas. Fishery Bulletin (U.S) 78:593-601.

Shane, S.H., Wells, R.S. and Wursig, B. 1986. Ecology, behavior and Social organization of the bottlenose dolphin: A review. Marine Mammal Science, 2, 34-63.

Walker, W.A. 1981. Geographical variation in morphology and biology of bottlenose dolphins (Tursiops) in the Eastern North Pacific, National Marine Fisheries Service/Southwest Fisheries Center Administrative Report No. LJ-81-03C, La Jolla, CA 92037

Wells, R.S. 1978. Home range characteristics and group composition of Atlantic bottlenosed dolphins, Tursiops truncatus on the west coast of Florida. M.Sc. thesis, University of Florida.

Wells, R.S., A.B. Irvine and M.D. Scott. 1980. The social ecology of inshore odontocetes. pp. 263-317. In L.M. Herman, (Ed.) Cetacean behavior: mechanisms and functions. John Wiley & Sons, New York. 463 p.

Wells, R.S., Dohl, T.P., Hansen, L.J., Baldridge, A.B. and Kelly, D.L. 1983. Extraordinary movements of bottlenose dolphins (Tursiops sp.) along the coast of California. Abstract. American Society of Mammalogists Annual Meeting. Humboldt State University, Arcata, CA.

Wursig, B. and M. Wursig. 1979. Behavior and ecology of bottlenose porpoises, Tursiops truncatus, in the South Atlantic. Fisheries Bulletin, 77, 871-890.

Table 1.

Sighting and Photographic Resight Data for Tursiops truncatus in the San Diego Study Area.

			Number of Animals Observed		Number of Animals Photographed		
Date	Time	Latitude	Total	Neonates	New	Resight	Total
01/25/84	13:51	33:12:00	4	0	0	0	0
02/08/84			0	0	0	0	0
02/13/84	12:10	33:09:30	12	1	2	2	4
02/19/84	09:50	32:55:30	6	0	0	0	0
02/24/84	10:41	33:02:30	7	0	0	0	0
02/07/84	13:56	33:10:30	15	1	0	0	0
02/28/84			0	0	0	0	0
03/09/84	11:50	32:54:00	10	0	0	5	5
03/17/84	08:50	33:03:00	27	7	2	8	10
03/23/84	11:01	32:56:00	7	1	0	1	1
03/24/84	10:03	33:05:00	27	1	11	13	24
04/15/84	14:17	33:06:30	10	1	0	1	1
05/11/84	10:50	32:57:00	19	2	0	0	0
05/12/84	09:32	32:57:00	10	2	0	0	0
05/26/84	09:30	32:55:30	40	4	0	0	0
06/15/84	09:01	32:56:30	7	0	2	3	5
06/18/84	10:24	32:59:30	30	0	9	5	14
07/02/84	08:43	32:55:30	9	1	3	0	3
07/06/84	09:19	32:55:00	4	0	1	2	3
07/07/84	08:25	32:57:00	9	0	2	5	7
07/13/84	09:48	32:57:00	15	1	5	6	11
07/16/84			0	0	0	0	0
07/20/84	10:47	33:02:30	7	0	1	3	4
07/27/84	09:15	32:57:30	15	0	1	0	1
08/03/84	10:08	32:55:30	7	0	2	2	4
08/08/84	08:38	32:52:30	2	0	0	0	0
08/10/84			0	0	0	0	0
08/17/84			0	0	0	0	0
08/24/84	09:30	32:59:00	47	2	3	2	5
09/07/84	09:46	33:01:30	15	0	1	0	1
09/15/84			0	0	0	0	0
09/17/84			0	0	0	0	0
10/05/84	10:20	32:59:00	2	0	0	2	2
10/08/84			0	0	0	0	0
10/19/84	15:21	32:46:00	6	0	2	1	3
10/26/84	10:30	33:03:00	3	0	0	3	3
10/29/84			0	0	0	0	0
11/02/84	10:35	32:55:30	4	0	1	1	2
11/26/84	10:54	32:58:30	18	6	2	6	8
11/30/84			0	0	0	0	0
02/06/85	09:52	33:13:00	14	4	2	2	4

Table 1. Continued

Date	Time	Latitude	Number of Animals Observed		Number of Animals Photographed		
			Total	Neonates	New	Resight	Total
02/08/85	10:06	32:52:00	90	20	5	6	11
02/15/85	08:16	32:55:30	25	3	5	2	7
02/22/85	10:33	32:57:00	9	0	3	1	4
02/27/85	11:17	32:54:30	8	0	3	1	4
03/06/85	09:13	33:09:30	9	0	4	2	6
03/13/85	09:17	32:59:30	4	0	0	0	0
03/20/85	09:06	32:59:30	2	0	0	0	0
04/10/85	09:32	32:59:00	4	0	2	1	3
04/17/85	09:12	32:54:00	50	9	2	2	4
04/22/85			0	0	0	0	0
05/01/85	10:27	32:58:30	6	0	3	0	3
05/08/85	10:01	32:57:30	29	12	13	3	16
06/23/85	07:39	32:59:00	11	3	5	1	6
06/26/85	07:38	32:59:00	11	3	5	0	5
07/01/85			0	0	0	0	0
07/11/85			0	0	0	0	0
07/24/85	07:01	32:54:30	15	3	2	2	4
07/29/85	07:24	32:55:30	29	9	4	3	7
07/31/85	09:07	32:59:00	11	1	7	1	8
08/21/85			0	0	0	0	0
09/25/85			0	0	0	0	0
10/13/85	09:26	32:56:00	20	1	0	0	0
10/16/85			0	0	0	0	0
10/23/85			0	0	0	0	0
11/06/85	08:47	32:54:00	23	2	17	2	19
11/16/85	10:10	32:55:30	35	4	14	4	18
12/19/85	09:38	32:58:00	35	2	18	7	25
01/27/86	15:40	32:59:00	2	0	0	0	0
02/12/86	10:30	32:59:30	25	4	11	3	14
02/22/86			0	0	0	0	0
03/19/86	08:00	32:59:30	9	3	0	1	1
03/19/86	09:00	33:02:00	30	3	10	6	16
03/21/86			0	0	0	0	0
04/11/86	09:45	33:06:00	17	3	3	3	6
04/20/86	09:25	33:00:30	14	2	7	2	9
04/25/86	07:45	32:52:30	3	0	0	0	0
04/25/86	08:10	32:56:00	6	1	2	0	2
05/14/86	09:50	32:59:30	3	1	0	0	0
05/23/86	09:16	32:57:00	5	0	2	0	2
05/26/86	09:15	32:57:00	11	0	4	0	4

Table 2.

Sighting and Photographic Resight Data for *Tursiops truncatus* in the Ensenada Study Area.

			Number of Animals Observed		Number of Animals Photographed		
Date	Time	Latitude	Total	Neonates	New	Resight	Total
04/20/85	08:30	31:48:00	27	3	13	10	23
07/06/85	07:15	31:50:00	32	3	6	6	12
07/27/85			0	0	0	0	0
07/28/85	08:30	31:50:00	16	5	6	2	8
09/14/85			0	0	0	0	0
10/05/85			3	1	0	0	0
10/26/85			0	0	0	0	0
05/03/86	08:50	31:48:00	18	1	9	2	11
05/10/86	07:15	31:49:00	25	0	13	5	18
06/07/86	07:15	31:49:00	45	11	19	5	24

Table 3.

Sighting and Photographic Resight Data for Tursiops truncatus in the Orange County Study Area. Blank spaces indicate missing data.

			Number of Animals Observed		Number of Animals Photographed		
Date	Time	Latitude	Total	Neonates	New	Resight	Total
10/29/82		33:39:20			1	1	2
11/04/82		33:39:20			0	2	2
11/06/82		33:42:00			1	1	2
11/12/82		33:40:00			0	1	1
12/29/82	09:20	33:21:10	22	4	2	0	2
05/21/83	12:45	33:41:30	6	1	1	0	1
07/18/83	08:49	33:41:30	6	0	0	1	1
07/18/83	09:47	33:37:45	22	0	3	0	3
07/29/83	08:04	33:37:45	42	0	1	0	1
07/31/83	14:15	33:20:45	32	4	5	2	7
08/03/83	08:42	33:41:30	27	0	11	3	14
08/07/83	08:25	33:42:00	27	0	6	3	9
11/02/83							
11/14/83							
11/30/83	08:30	33:40:00	22	4	4	2	6
12/13/83	08:51	33:37:45	27	0	7	5	12
12/27/83		33:27:45			2	0	2
03/16/84		33:38:50			1	3	4
03/17/84		33:40:00			1	0	1
04/09/84							
04/18/84	10:00	33:38:50	27	2	4	2	6
04/22/84	10:00	33:37:40	37	0	8	4	12
05/14/84							
07/03/84							
09/29/84	12:27	33:41:30	22	5	2	3	5
10/28/84	09:26	33:39:20	5	0	4	0	4
11/11/84							
12/02/84	12:20	33:20:05	15	3	7	2	9
02/23/85	10:00	33:21:30	19	2	9	1	10
03/16/85							
09/08/85	09:42	33:42:00	27	2	3	0	3
09/15/85							
10/06/85	09:00	33:33:30	27	0	13	6	19
12/15/85	07:00	33:27:20	7	0	3	0	3
02/23/86		33:25:00			6	5	11

Table 4. Group Size Mean, Standard Deviation, Median, Range and Totals for San Diego, Ensenada and Orange County Study Areas.

	San Diego / Ensenada	Orange County
Mean	16	22
(SD)	(14.7)	(10.1)
Median	11	22
Range	2 - 90	5 - 42
Total	959 (San Diego) 166 (Ensenada)	416

Table 5.

Proportion of photographically identifiable animals which were resighted. Proportions are presented in blocks of 5 trips where at least one animal was identified. Dates of the first and last trip of each block are given.

Block Number	1	2	3	4	5	6	7	8	9
Dates	3/17 to 6/15	6/18 to 7/13	7/20 to 9/7	10/5 to 11/26	2/6 to 2/27	3/6 to 5/8	6/23 to 7/31	11/6 to 3/19	4/11 to 5/26
Year	<---------- 1984 ----------><---------- 1985 ----------><- 1986 ->								
Sample Size	41	38	15	18	30	32	30	93	23
CBL	0%	21%	20%	11%	27%	53%	53%	55%	74%
CBL & NMFS	37%	53%	53%	28%	60%	75%	77%	75%	78%

Figure 1. Computation of Dorsal Ratio. See Text for Details

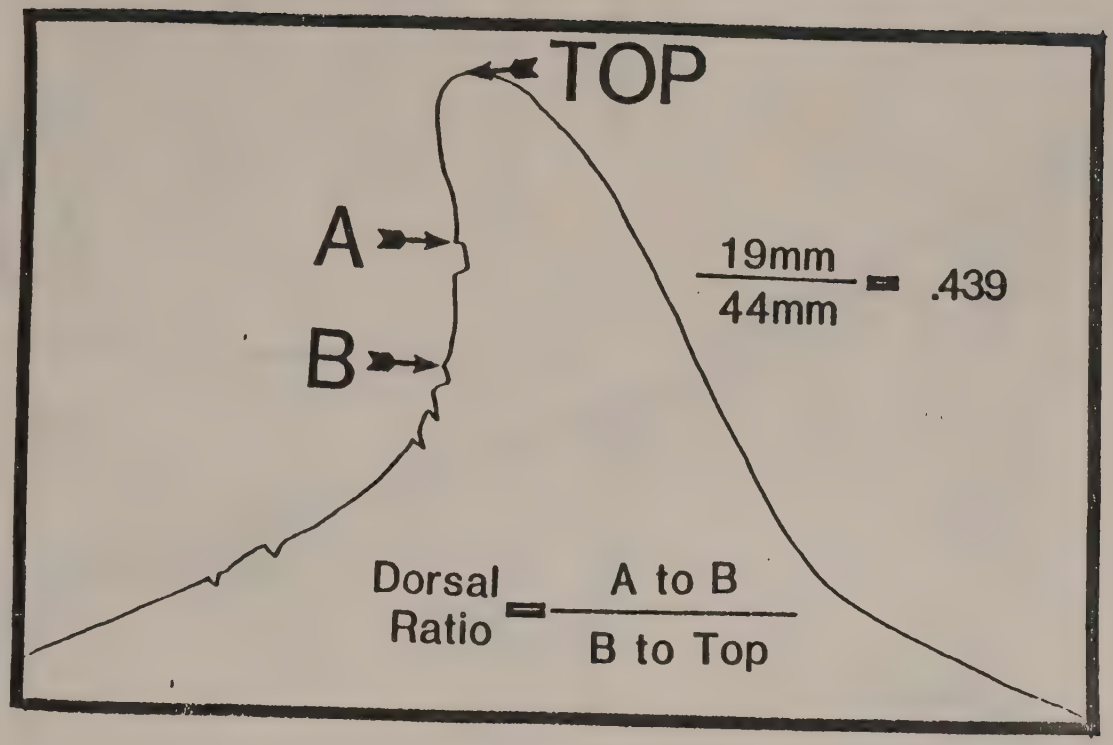

TOP
A
B
19mm / 44mm = .439
Dorsal Ratio = A to B / B to Top

Figure 2. Map of the San Diego Study Area. Insert shows relative location of Orange County, San Diego and Ensenada Study areas.

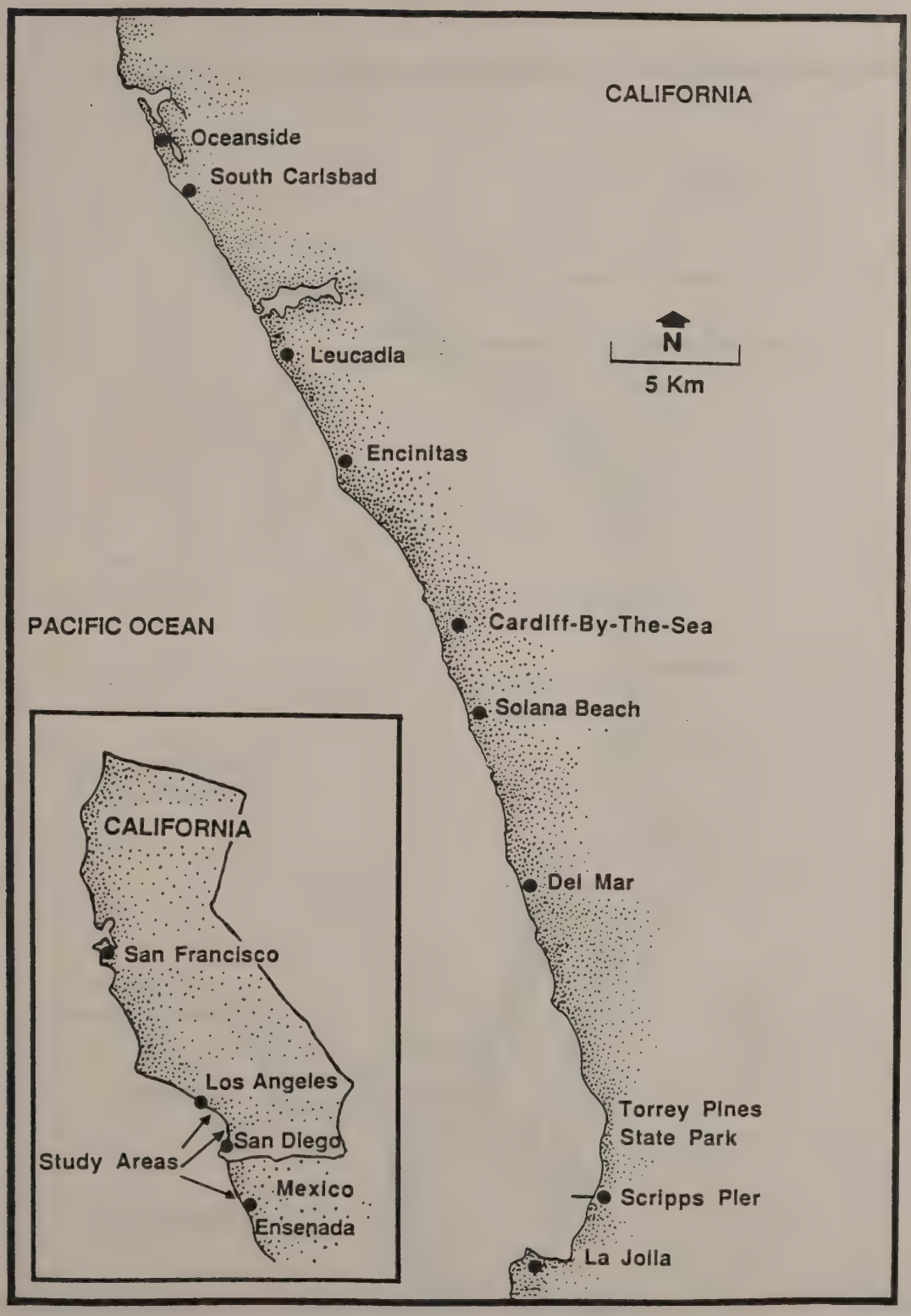

CALIFORNIA
Oceanside
South Carlsbad
N
5 Km
Leucadia
Encinitas
PACIFIC OCEAN
Cardiff-By-The-Sea
Solana Beach
CALIFORNIA
Del Mar
San Francisco
Los Angeles
Torrey Pines
State Park
San Diego
Study Areas
Mexico
Scripps Pier
Ensenada
La Jolla

Figure 3. Map of the Ensenada Study area.

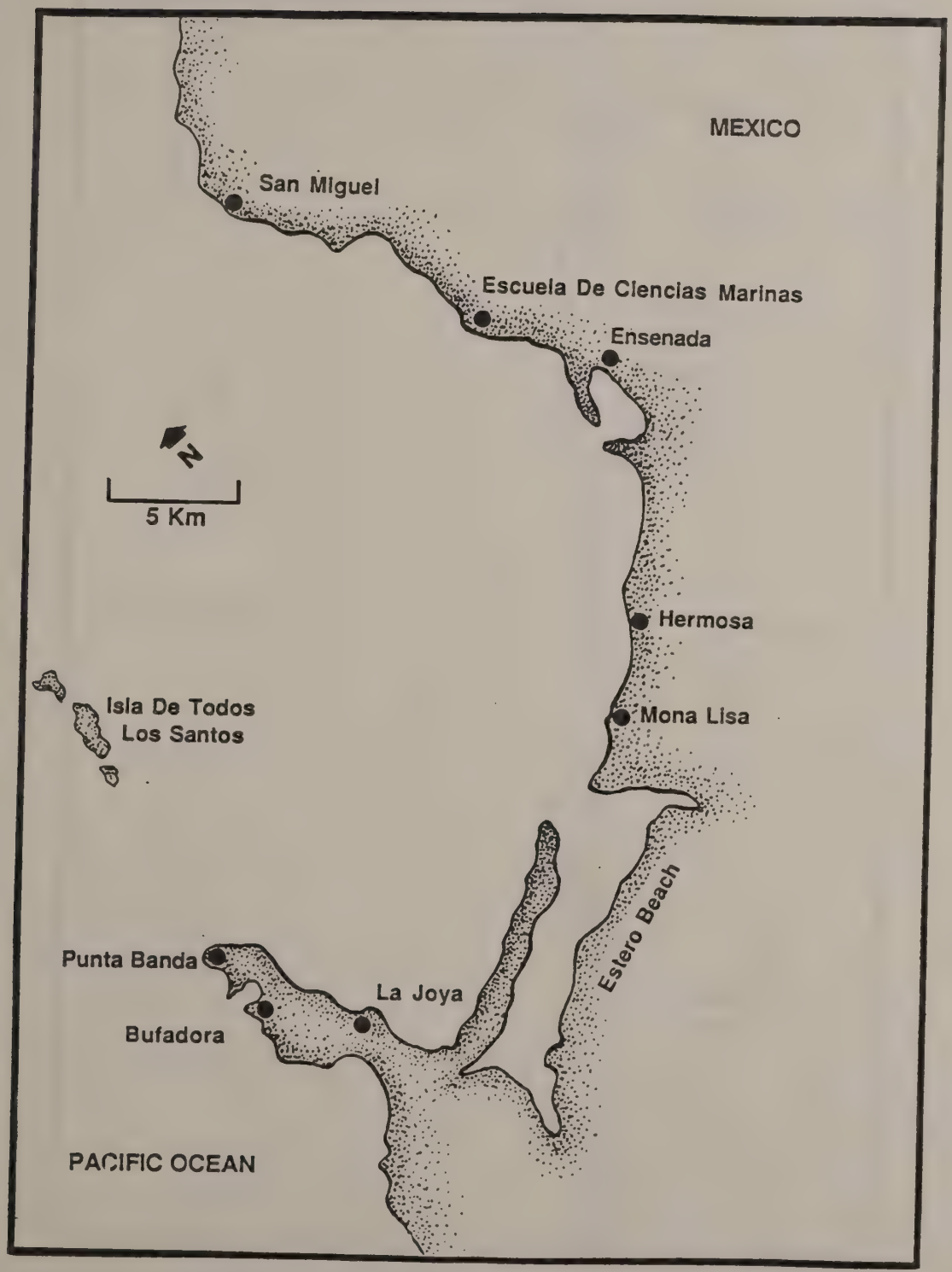
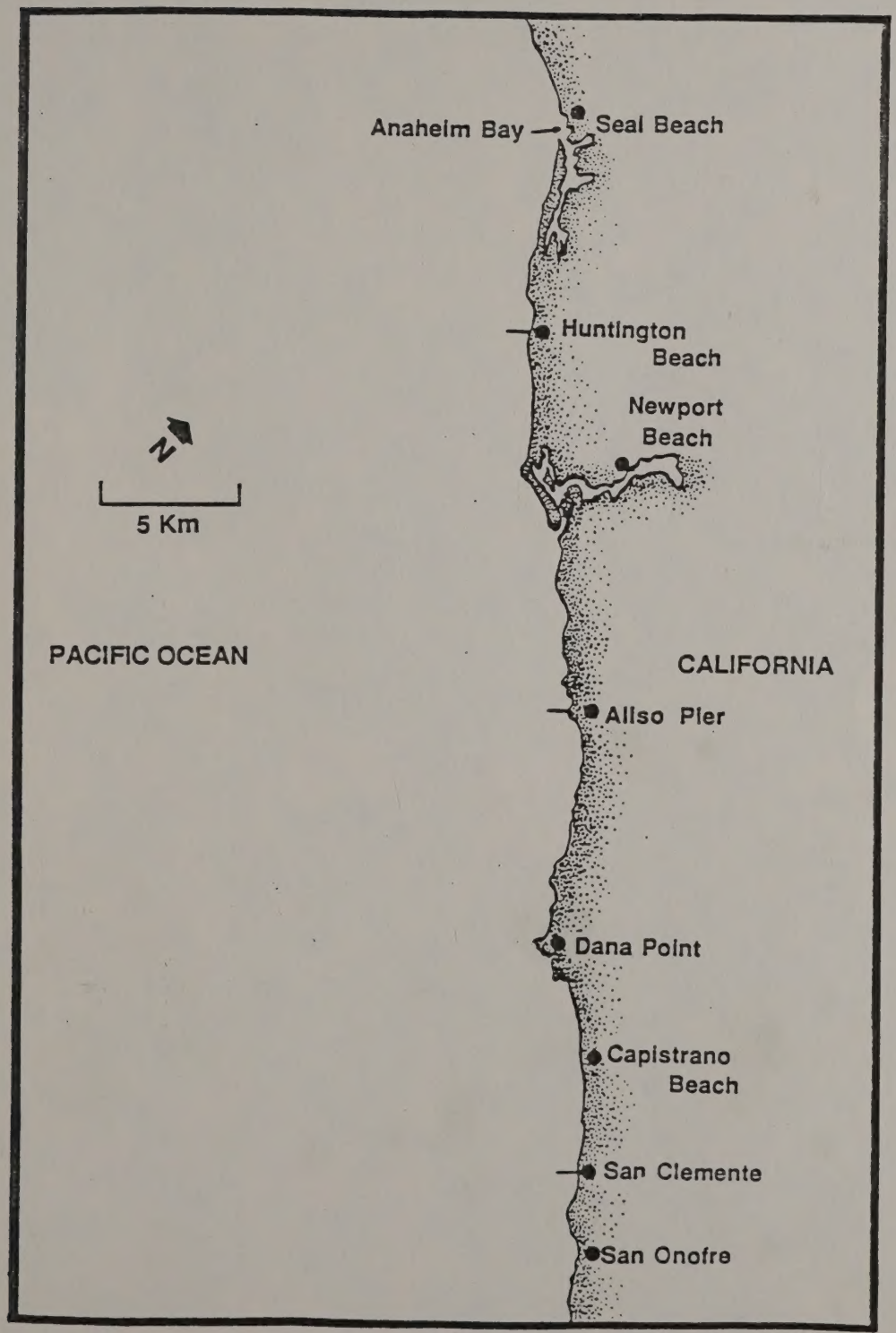

MEXICO
San Miguel
Escuela De Ciencias Marinas
Ensenada
N
5 Km
Hermosa
Isla De Todos
Los Santos
Mona Lisa
Estero Beach
Punta Banda
La Joya
Bufadora
PACIFIC OCEAN

Figure 4. Map of Orange County Study Area.


Anaheim Bay
Seal Beach
Huntington Beach
Newport Beach
N
5 Km
PACIFIC OCEAN
CALIFORNIA
Allso Pier
Dana Point
Capistrano Beach
San Clemente
San Onofre